Claims

What is claimed is:

1. A free piston engine comprising:

an energy storage and control assembly having a first side;

a first combustion cylinder assembly located adjacent to the first side of the energy storage and control assembly and including a first cylinder liner that defines a generally cylindrical first engine cylinder, which is centered about an axis of motion, with the first engine cylinder having a cylinder diameter, and with the first cylinder liner including an exhaust port and an intake port extending therethrough;

an outer piston assembly having a first outer piston located and telescopically slidable within the first engine cylinder along the axis of motion and having a first outer piston head facing the energy storage and control assembly, with the first outer piston including a first piston bridge located on an opposed end of the first outer piston from the first outer piston head, with the first piston bridge having an oval outer surface with a maximum diameter that is larger than the cylinder diameter of the first engine cylinder, and with the outer piston assembly including a first outer rod mounted to the first piston bridge and operatively engaging the energy storage and control assembly;

a first scavenge pump engaged with the first combustion cylinder and having a first scavenge pump housing, which defines an air inlet, an air outlet and includes a wall that defines a main pumping chamber selectively connectable to the air inlet and the air outlet, with the main pumping chamber telescopically receiving the first piston bridge therein and the wall being cylindrical in shape and having an oval cross section such that the oval outer surface of the first piston bridge seals against the wall; and

a turbocharger having a turbine in fluid communication with an inlet adapted for receiving exhaust gases from the exhaust port of the first combustion cylinder, and a compressor that is rotationally driven by the

turbine and in fluid communication with an outlet that is in fluid communication with the air inlet of the first scavenge pump.

2. The free piston engine of claim 1 wherein:

the energy storage and control assembly further includes a second side in opposed relation to the first side;

the free piston engine further includes a second combustion cylinder assembly located adjacent to the second side of the energy storage and control assembly and has a second cylinder liner that defines a generally cylindrical second engine cylinder, which is centered about the axis of motion, with the second engine cylinder having a second cylinder diameter, and with the second cylinder liner including an exhaust port and an intake port extending therethrough;

the outer piston assembly includes a second outer piston located and telescopically slidable within the second engine cylinder along the axis of motion and having a second outer piston head facing the second side, and further includes a second piston bridge located on an opposed end of the second outer piston from the second outer piston head, with the second piston bridge having a generally oval outer surface with a maximum diameter that is larger than the second cylinder diameter and being connected to a second outer rod that operatively engages the energy storage and control assembly; and

a second scavenge pump engaged with the second combustion cylinder and having a second scavenge pump housing, which defines an air inlet, an air outlet and includes a wall that defines a second main pumping chamber selectively connectable to the air inlet and the air outlet, with the second main pumping chamber telescopically receiving the second piston bridge therein and the wall being cylindrical in shape and having an oval cross section such that the oval outer surface of the second piston bridge seals against the wall of the second main pumping chamber, and with the air inlet of the second scavenge pump in fluid communication with the outlet of the compressor.

3. The free piston engine of claim 2 wherein the first outer rod is mounted to the second piston bridge and the second outer rod is mounted to the first piston bridge.

4. The free piston engine of claim 3 further including an inner piston assembly having a first inner piston located and telescopically slidable within the first engine cylinder along the axis of motion and an inner rod mounted to the first inner piston and operatively engaging the energy storage and control assembly, and a second inner piston located and telescopically slidable within the second engine cylinder along the axis of motion and mounted to the inner rod.

5. The free piston engine of claim 4 wherein the energy storage and control assembly includes a fluid pumping assembly having an inner fluid pumping chamber and an outer fluid pumping chamber, a source of fluid under a relatively high pressure that is selectively in fluid communication with the inner fluid pumping chamber and the outer fluid pumping chamber, and a source of fluid under a relatively low pressure that is selectively in fluid communication with the inner fluid pumping chamber and the outer fluid pumping chamber, and with the inner rod extending and telescopically slidable through the inner fluid pumping chamber and the first outer rod extending and telescopically slidable through the outer fluid pumping chamber.

6. The free piston engine of claim 1 wherein the first outer piston defines a hollow cavity therein that is open to the first piston bridge, and the first piston bridge includes a web that defines an opening extending between the hollow cavity and the main pumping chamber.

7. The free piston engine of claim 6 wherein the first combustion cylinder assembly further includes a first air intake channel in fluid communication with the intake port; and the web of the first piston bridge

includes a pair of closed portions, with each closed portion having a side facing away from the main pumping chamber that is in fluid communication with the first air intake channel.

8. The free piston engine of claim 1 wherein the outer piston assembly further includes a second outer rod mounted to the first piston bridge and operatively engaging the energy storage and control assembly.

9. The free piston engine of claim 1 further including an intercooler heat exchanger having an inlet in fluid communication with the air outlet of the first scavenge pump and an outlet in fluid communication with the intake port of the first combustion cylinder.

10. The free piston engine of claim 9 further including an external exhaust gas recirculation assembly having an inlet in fluid communication with the exhaust port of the first combustion cylinder and an outlet in fluid communication with the air inlet of the first scavenge pump.

11. The free piston engine of claim 1 further including a wastegate connected between the exhaust port and the inlet of the turbocharger, and a bypass tube, with the wastegate switchable for selectively diverting a portion of exhaust gasses flowing from the exhaust port through the bypass tube instead of to the inlet of the turbocharger.

12. A free piston engine comprising:

an energy generation and control assembly having a first side and a second side in opposed relation to the first side;

a first combustion cylinder assembly located adjacent to the first side of the energy generation and control assembly and including a first cylinder liner that defines a first engine cylinder, which is centered about an axis of motion, and with the first cylinder liner including a plurality of circumferentially spaced exhaust ports and a plurality of circumferentially spaced intake ports;

a second combustion cylinder assembly located adjacent to the

second side of the energy generation and control assembly and including a second cylinder liner that defines a second engine cylinder, which is centered about the axis of motion, and with the second cylinder liner including a plurality of circumferentially spaced exhaust ports and a plurality of circumferentially spaced intake ports;

an inner piston assembly having a first inner piston with a first inner piston head and a second inner piston with a second inner piston head, with the first inner piston mounted in the first engine cylinder such that the first inner piston head faces away from the first side and is telescopically slidable within the first engine cylinder along the axis of motion, and with the second inner piston mounted in the second engine cylinder such that the second inner piston head faces away from the second side and is telescopically slidable within the second engine cylinder along the axis of motion, and with the inner piston assembly further including a push rod having a first end affixed to the first inner piston and a second end affixed to the second inner piston and a middle portion extending through the energy generation and control assembly;

an outer piston assembly having a first outer piston with a first outer piston head and a second outer piston with a second outer piston head, and with the first outer piston mounted in the first engine cylinder such that the first outer piston head faces toward the first inner piston head and is telescopically slidable within the first engine cylinder, and with the second outer piston mounted in the second engine cylinder such that the second outer piston head faces toward the second inner piston head and is telescopically slidable within the second engine cylinder, and with the outer piston assembly further including a first pull rod having a first end affixed to the first outer piston and a second end affixed to the second outer piston and a middle portion extending through the energy generation and control assembly; and

a turbocharger having a turbine including an inlet in fluid communication with the exhaust ports of the first combustion cylinder and the exhaust ports of the second combustion cylinder, and a compressor that is rotationally driven by the turbine and including an outlet that is in fluid

communication with the intake ports of the first combustion cylinder and the exhaust ports of the second combustion cylinder.

13. The free piston engine of claim 12 wherein the plurality of exhaust ports in the first combustion cylinder are spaced from a bottom dead center position of the first inner piston about the same distance as the plurality of intake ports in the first combustion cylinder are spaced from a bottom dead center position of the first outer piston

14. The free piston engine of claim 13 wherein the plurality of exhaust ports in the second combustion cylinder are spaced from the bottom dead center position of the second inner piston about the same distance as the plurality of intake ports in the first combustion cylinder are spaced from a bottom dead center position of the second outer piston.

15. The free piston engine of claim 12 further including a first scavenge pump having an air inlet that is in fluid communication with the outlet of the turbocharger compressor and an air outlet that is in fluid communication with the plurality of intake ports of the first combustion cylinder, and with the scavenge pump having a piston in a pumping chamber that is drivable by the first outer piston.

16. The free piston engine of claim 15 further including a second scavenge pump having an air inlet that is in fluid communication with the outlet of the turbocharger compressor and an air outlet that is in fluid communication with the plurality of intake ports of the second combustion cylinder, and with the scavenge pump having a piston in a pumping chamber that is drivable by the second outer piston.

17. The free piston engine of claim 15 further including an intercooler heat exchanger having an inlet in fluid communication with the air outlet of the first scavenge pump and an outlet in fluid communication with the plurality of intake ports of the first combustion cylinder.

18. A free piston engine assembly comprising:

a first free piston engine including an energy generation and control assembly having a first side and a second side in opposed relation to the first side; a first combustion cylinder assembly located adjacent to the first side of the energy generation and control assembly and including a first cylinder liner that defines a first engine cylinder, and with the first cylinder liner including an exhaust port and an intake port; a second combustion cylinder assembly located adjacent to the second side of the energy generation and control assembly and including a second cylinder liner that defines a second engine cylinder, and with the second cylinder liner including an exhaust port and an intake port; and a first piston assembly having a first piston located and telescopically slidable within the first engine cylinder, a second piston located and telescopically slidable within the second engine cylinder, and a driven rod affixed between the first and second pistons and having a middle portion extending through and engaging the energy generation and control assembly;

a second free piston engine including a second energy generation and control assembly having a first side and a second side in opposed relation to the first side; a third combustion cylinder assembly located adjacent to the first side of the second energy generation and control assembly and including a third cylinder liner that defines a third engine cylinder, and with the third cylinder liner including an exhaust port and an intake port, a second combustion cylinder assembly located adjacent to the second side of the second energy generation and control assembly and including a fourth cylinder liner including an exhaust port and an intake port, and a second piston assembly having a third piston located and telescopically slidable within the third engine cylinder , and a fourth piston located and telescopically slidable within the fourth engine cylinder, and a second driven rod affixed between the third and fourth pistons and having a middle portion extending through and engaging the second energy generation and control assembly; and

a turbocharger having a turbine including an inlet adapted to be in

fluid communication with exhaust from the exhaust ports of the first, second, third and fourth combustion cylinders, and having a compressor that is rotationally driven by the turbine and includes an outlet that is in adapted to be in fluid communication with the intake ports of the first, second, third and fourth combustion cylinders.

19. The free piston engine assembly of claim 18 further including a first scavenge pump having an air inlet that is in fluid communication with the outlet of the turbocharger compressor and an air outlet that is in fluid communication with the intake port of the first combustion cylinder.

20. The free piston engine assembly of claim 19 further including a second scavenge pump having an air inlet that is in fluid communication with the outlet of the turbocharger compressor and an air outlet that is in fluid communication with the intake port of the second combustion cylinder.